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An annotated distributional checklist of exotic freshwater fishes from the Baja California Peninsula, Mexico

Lista comentada sobre la distribución de peces dulceacuícolas exóticos de la península de Baja California, México

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Abstract. We documented the distributional status of 27 exotic fish species in the inland waters of the Baja California Peninsula, Mexico, based on voucher specimens collected from 122 sites between 1977 and 2010, and on published records. The species reported here are representatives of genera from the Atlantic drainages of North America (*Ictalurus*, *Ameiurus*, *Pylodictis*, *Morone*, *Lepomis*, *Pomoxis*, *Dorosoma*, *Cyprinella*, and *Micropterus*), Middle America (*Poecilia*, *Gambusia*, and *Xiphophorus*), Eurasia (*Cyprinus* and *Carassius*), and Africa (*Tilapia* and *Oreochromis*). The family containing the highest number of species is Centrarchidae (7 species) followed by Ictaluridae and Poeciliidae (6 species each). Four species were determined to be invasive due to their wide distribution and fast dispersal through the Peninsula (*Gambusia affinis*, *Poecilia reticulata*, *Lepomis cyanellus*, and *Tilapia* sp. cf. *zillii*). We analyze the impacts of exotic species on the native populations of 3 species with problems of conservation: *Cyprinodon macularius* (endangered), *Fundulus lima* (endangered), and *Gasterosteus aculeatus* (vulnerable). Alien fishes have been introduced for a variety of reasons in Mexico: ornament, sport, aquaculture, biological control, and by accident. In some cases fish introductions were carried out for more than one reason.

Key words: alien fishes, freshwater, Baja California Peninsula, impacts, curatorial records.

Resumen. El estatus de la distribución de peces exóticos es documentado para 27 especies en las aguas continentales de la península de Baja California, México, basado en registros de ejemplares recolectados en 122 localidades durante el período de 1977 a 2010, así como registros referidos en la literatura. Las especies aquí reportadas son representativas de géneros que proceden de la vertiente Atlántica de Norteamérica (*Ictalurus*, *Ameiurus*, *Pylodictis*, *Morone*, *Lepomis*, *Pomoxis*, *Dorosoma*, *Cyprinella* y *Micropterus*), Mesoamérica (*Poecilia*, *Gambusia* y *Xiphophorus*), Eurasia (*Cyprinus* y *Carassius*) y África (*Tilapia* y *Oreochromis*). La familia con mayor número de especies es Centrarchidae (7 especies) seguida por Ictaluridae y Poeciliidae (con 6 especies cada una). Por su amplia distribución y rápida dispersión en la península, 4 especies son determinadas como invasivas (*Gambusia affinis*, *Poecilia reticulata*, *Lepomis cyanellus* y *Tilapia* sp. cf. *zillii*). Se analizan los impactos de las especies exóticas sobre las poblaciones nativas de 3 especies con problemas de conservación: *Cyprinodon macularius* (peligro de extinción), *Fundulus lima* (peligro de extinción) y *Gasterosteus aculeatus* (vulnerable). Las especies exóticas se han introducido en México por varias causas: ornamental, pesca deportiva, acuicultura, control biológico y la liberación intencionada. En algunos casos, las introducciones de peces se llevan a cabo por más de una causa.

Palabras clave: peces exóticos, aguas continentales, península de Baja California, impactos, registros curatoriales.

Introduction

The stability and integrity of the fish communities in the arid and semiarid regions of northern Mexico are being threatened by the progressive introduction of exotic or non-native fishes (Contreras-Balderas et al., 2008). In inland waters of Mexico at least 113 exotic fish have been reported (Contreras-Balderas et al., 2008), and this number could increase if control and eradication programs are not implemented in time and space. The problem of exotic

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species, particularly when they become invasive, is more severe when these species are introduced in ecosystems with low species richness such as occur in springs and oases, displacing or eliminating native species that have evolved in isolation for thousands of years with little competition (Douglas et al., 1994).

The introduction of a non-native species in an ecosystem is always likely to present an ecological risk if the species is able to integrate itself successfully into the ecosystem (Gozlan and Newton, 2009), resulting in possible detrimental interactions with native species or even on ecosystem functioning. The introduced species could affect biodiversity through predation (Mc Dowall, 2006; Weyl and Lewis, 2006; Bampfylde and Lewis, 2007; Yonekura et al., 2007), competition (Caiola and Sostoa, 2005; McDowall, 2006; Zimmerman and Vondracek, 2006; Blanchet et al., 2007), hybridization (Allendorf et al., 2004; Costedoat et al., 2004, 2005; Hänfling et al., 2005; D'Amato et al., 2007), habitat modification (Kitchell et al., 1997; Tejerrina-Garro et al., 2005; McDowall, 2006), and transmission of diseases (Daszak et al., 2000; Gaughan, 2002; Gozlan et al., 2005, 2006).

One of the main effects of the gradual elimination of native species and their replacement by exotics is the homogenization of the biota, which causes a loss of the biodiversity and changes in the function of the ecosystem (McKinney and Lockwood, 1999; Mack et al., 2000; Marchetti et al., 2001; Rahel, 2002). Records of exotic fishes in northwestern Mexico were partially covered in 2 contributions by Contreras-Balderas and Escalante-Cavazos (1984) and Contreras-Balderas (1999).

From a regional point of view, 17 exotic fish species have been reported for Baja California (Ruiz-Campos and Contreras-Balderas, 1987; Ruiz-Campos et al., 2000) and 6 species for Baja California Sur (Ruiz-Campos et al., 2003). Varela-Romero et al. (2003) evaluated the impact of exotic redbelly tilapia [*Tilapia* sp. cf. *zillii* (Gervais, 1848)] on the native populations of the desert pupfish *Cyprinodon macularius* Baird and Girard, 1853 in different sites of the lower Río Colorado basin of Sonora and Baja California. These authors documented the extirpation of the native pupfish at several historic sites in Baja California (cf. Follett, 1960; Hendrickson and Varela, 1989). Likewise, Ruiz-Campos et al. (2006, 2008) and Ruiz-Campos (2010) evaluated the impact of redeblly tilapia on the distribution and abundance of the endemic Baja California killifish *Fundulus lima* Vaillant, 1894 in the oases of San Ignacio and La Purísima of Baja California Sur, documenting the strong decline of the endemic fish at the type locality of oasis San Ignacio.

This work documents the distribution of exotic fish species and their impacts on the native fish fauna in the Baja California Peninsula, Mexico, on the basis of voucher specimens from scientific collections or records referred to in the literature during a period of 33 years. This distributional information might be used for the planning, implementation, and performance of programs focused on evaluation, eradication, and control of these alien species, as well as their interaction with the native biota.

Material and methods

The records supporting this study are based on voucher specimens of exotic species (Appendix 1) that have been collected for 122 freshwater sites in the Mexican states of Baja California and Baja California Sur (Fig. 1; Appendix 2), between 1977 and 2010.

The fish were captured using different types of fishing gear according to the habitat of each species. In shallow habitats (< 1.5 m deep) active capture methods were used (seine: 7.8 m long x 1.9 m height with 3.5 mm bar mesh; and minnow traps: 45 cm long, 6.4 mm mesh netting, and 2.2 cm openings at both ends); while in those sites deeper than 1.5 m experimental gillnets (with 6 m panels with mesh sizes of 1.3, 3.8, 7.6 and 10.2 cm) and cast nets (4 m diameter with 2.54 cm bar mesh) were used. Electrofishing equipment (Smith-Root 15-C P.O.W. and Coffelt BP-6) was used for shallow habitat with low salinity (< 0.5 ppt), such as in the headwaters of streams (Sierra San Pedro Mártir).

Samples of collected fish species were fixed in the field with a 10% formalin solution and transported to the laboratory for analysis and identification. After 7 days, the fish samples were washed with water for 1 day, and finally preserved with 50% ethanol. The fish material was deposited in the following fish collections: the Facultad de Ciencias of the Universidad Autónoma de Baja California (UABC), the Departamento de Investigación Científica of the Universidad de Sonora (USON), and the Facultad de Ciencias Biológicas of the Universidad Autónoma de Nuevo León (UANL). Collecting records of fish specimens previous to 1983 were documented from the fish collections of the California Academy of Sciences (CAS), San Francisco, California (USA); the Facultad de Ciencias Biológicas, Universidad Autónoma de Nuevo León (UANL), Monterrey, N.L. (Mexico); Centro Interdisciplinario de Ciencias Marinas (CICIMAR), Instituto Politécnico Nacional, La Paz, B.C.S. (Mexico); and Museo Regional de Historia Natural, Universidad Autónoma de Baja California Sur (UABCS).

The scientific names and taxonomic arrangements of the species follows Eschmeyer (1998). For each species a synopsis is provided that includes the following information: *Common name:* common names of the species

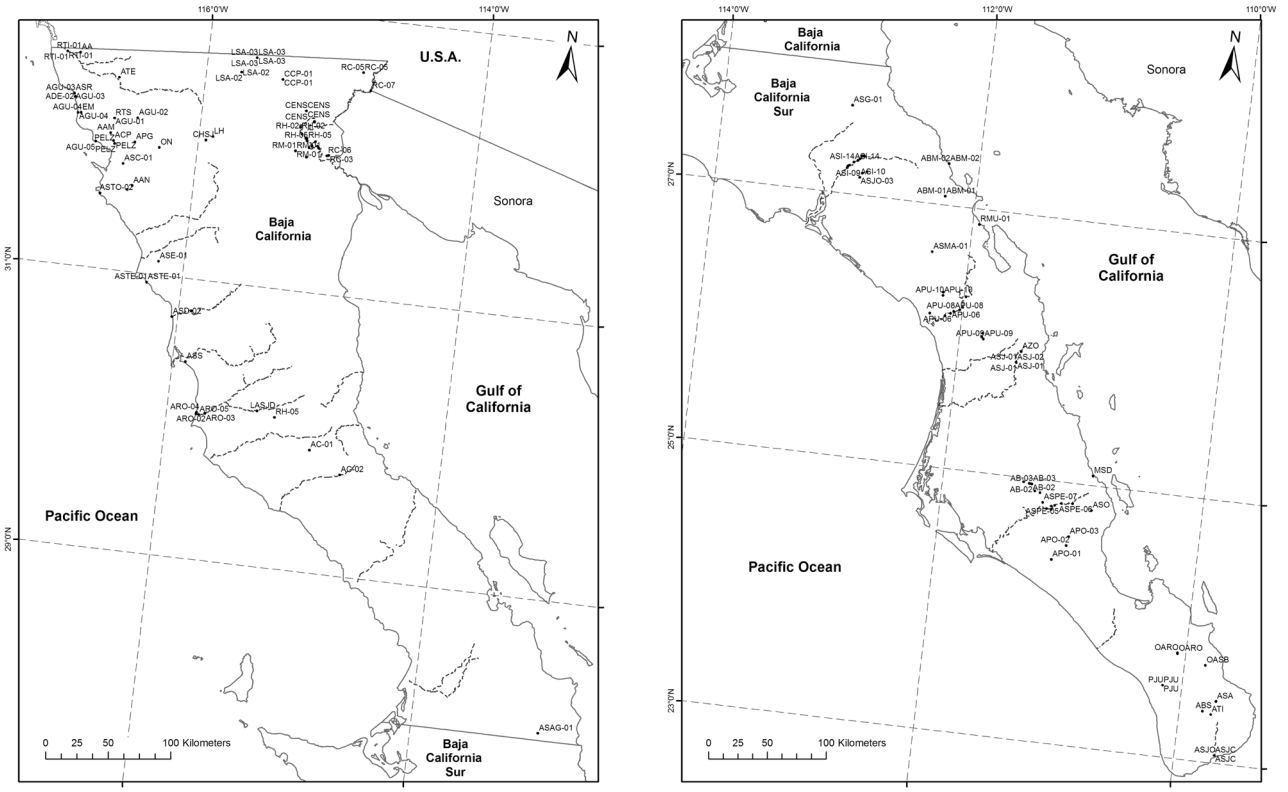

Figure 1. Collecting sites in the Baja California Peninsula, Mexico (see codes and toponymy in Appendix 2).

both in Spanish and English based on Nelson et al. (2004). *Native range*: native distribution range of the species based on published records. *Previous records*: includes those records for Baja California and Baja California Sur based on voucher specimens or on reports published previous to 1983. *Recent records*: includes those records for these states supported with voucher specimens that are indicated with the catalog number in collections and number of specimens (cf. Appendix 1), or as a visual report. Other information appears in parentheses. *Comments:* information regarding the non-native distribution of the taxon, or documentation of the impacts on the distribution and abundance of the native fish fauna.

Results

Twenty seven exotic fish species belonging to 16 genera and 7 families were documented for 122 sites of inland waters on the Baja California Peninsula. The species reported here are representatives of genera from the Atlantic drainages (*Ictalurus*, *Ameiurus*, *Pylodictis*, *Morone*, *Lepomis*, *Pomoxis*, *Dorosoma*, *Cyprinella*, and *Micropterus*), Middle America (*Poecilia*, *Gambusia*, and *Xiphophorus*), Eurasia (*Cyprinus* and *Carassius*), and Africa (*Tilapia* and *Oreochromis*). A synopsis for each species is provided as follows:

Order Clupeiformes
Family Clupeidae
Dorosoma petenense (Günther, 1867)
Common name: threadfin shad/sardina Maya.
Native range: from the Ohio River of Kentucky and southern Indiana, west and south into Oklahoma, Texas and Florida, and along the Gulf of Mexico Coast into Mexico and Central America (Ross, 2002).
Previous records. Baja California: lower Río Colorado (Minckley, 2002 [as *Dorosoma mexicana*], Miller et al. 2005). *Baja California Sur:* none.
Recent records. Baja California: channel tributary to Laguna Salada; Río Colorado (2 localities: before junction with Río Hardy and Ejido Yucumuri); Río El Mayor at Campo Sonora; Presa Emilio López Zamora; Río Hardy (2 localities: before junction with the Río Colorado and Campo Mosqueda); and irrigation channel between Ejido Nayarit and Ejido Sonora. *Baja California Sur:* none (Appendixes 1, 2).
Comments: this shad native to the Atlantic drainage of America was introduced in the Río Colorado (Lake

Havasu) in 1954, mainly as forage fish for the black largemouth bass (*Micropterus salmoides* Lacépède, 1802) and other sport fishes (Dill and Cordone, 1997). Although Minckley (2002) pointed out the presence of this fish as *D. mexicana* Günther for the lower Río Colorado of Mexico; he did not detail collecting sites or voucher specimens.

Order Cypriniformes
Family Cyprinidae
Cyprinella lutrensis (Baird and Girard, 1853)
Common name: beautiful shinner/carpita roja.
Native range: Mississippi River basin from southern Wisconsin and eastern Indiana to South Dakota and Wyoming, and south to Louisiana; Gulf of Mexico drainages to Río Grande, Texas (New Mexico) and the Río Colorado (Page and Burr, 1991). Widely introduced in the United States (Fuller et al., 1999) and the lower Río Colorado of Mexico (Contreras-Balderas and Escalante-Cavazos, 1984; Varela-Romero et al., 2003) and Río Yaqui (Contreras-Balderas, 1999).
Previous records. Baja California: Río Hardy downstream of El Mayor (Follett, 1960). *Baja California Sur*: none.
Recent records Baja California: Río Hardy at Campo Mosqueda; Río Colorado at Ejido Yucumuri; and irrigation channel between Ejido Nayarit and Ejido Sonora (Varela-Romero et al., 2003). *Baja California Sur*: none (Appendixes 1, 2).
Comments: the first finding of red shiner in the lower Río Colorado basin of Mexico (San Luis Colorado River) occurred in January 1953 (Hubbs, 1954; Dill and Cordone, 1997). It is very possible that the extirpation of desert pupfish *C. macularius* in the Río Colorado and the irrigation channels between Ejido Nayarit and Ejido Sonora is associated with the presence of red shiner (Varela-Romero et al., 2003).
Cyprinus carpio Linnaeus, 1758
Common name: common carp/carpa común.
Native range: Eurasia (Page and Burr, 1991).
Previous records. Baja California: Río Colorado and its tributaries (Follett, 1960), as well as Laguna Salada (= Maquata) at La Playita (Ruiz-Campos and Contreras-Balderas, 1987). *Baja California Sur*: none.
Recent records. Baja California: Laguna Salada (2 localities: channel tributary and La Playita); and Río Colorado before confluence with Río Hardy. *Baja California Sur*: Arroyo San Ignacio (spring, bridge, Poza Larga, Rancho Los Corralitos, Lake Side, and Rancho San Sabas; Ruiz-Campos et al., 2006) (Appendixes 1, 2).
Comments: the presence of this Eurasian cyprinid in Baja California was first documented by Follett (1960) for the Río Colorado and its tributaries in the Mexicali Valley. In Baja California Sur, common carp was stocked in the oasis San Ignacio in 1973 to promote rural fish farming (Ruiz-Campos et al., 2003). In both cases, the consumption of this fish is uncommon due to the bad flavor of its flesh and the ease of obtaining fresh fish from the San Ignacio coastal lagoon. Two morphs have been detected in the Baja California Peninsula, the "mirror morph" in the Arroyo San Ignacio and the "normally scaled morph" in the lower Río Colorado basin (Ruiz-Campos, 2010).
Carassius auratus **(**Linneaus, 1758)
Common name: goldfish/carpa dorada.
Native range: Eastern Asia, including China and perhaps adjacent regions; also possibly in parts of Europe if *C. auratus gibelio* is a valid subspecies and not just a feral introduction (Fuller et al., 1999).
Previous records: none.
Recent records. Baja California: Río Hardy before junction with Río Colorado; Laguna Salada at Paraíso fishery camp; and irrigation channel between Ejido Nayarit and Ejido Sonora. *Baja California Sur*: none (Appendixes 1, 2).
Comments: this Asian fish dispersed worldwide by the aquarist industry when it was introduced in waters of California between 1882 and 1884, and currently its distribution has expanded through the State when they interbreed with common carp (Dill and Cordone, 1997). Its presence in the lower Río Colorado basin is considered rare and resulting from releasing by aquarists.

Order Siluriformes
Famiy Ictaluridae
Ictalurus furcatus (Lesueur, 1840)
Common name: blue catfish/bagre azul.
Native range: native to major rivers of the Mississippi, Missouri, and Ohio basins of central and southern United States, south into Mexico and northern Guatemala (Lee et al., 1980). The southernmost populations of blue catfish in Mexico have been considered as *I. meridionalis* (Ruiz-Campos et al., 2009; Rodiles-Hernández et al., 2010).
Previous records: none.
Recent records. Baja California: Laguna Salada; Lago del Bosque in Mexicali; and tributaries of the Río Colorado such as El Caimán, Hardy and El Mayor, including the Canal Todo Americano (G. Ruiz-Campos, pers. obs.). *Baja California Sur*: none.
Comments: certainly, this exotic catfish known as "puyón" in northwestern Mexico was stocked in waters of the Mexicali Valley as a sport fish. It prefers swift waters or turbulent areas with rocky bottoms. No voucher specimens are available, but all records are supported with photographs.
Ictalurus punctatus (Rafinesque, 1818)
Common name: channel catfish/bagre de canal.
Native range: native to central drainages of the United States, southern Canada, and possibly also in the Atlantic

coast (Lee et al., 1980), including southern Florida and the lower Río Bravo (Grande), south through the Gulf of Mexico drainages to Río Cazones, Veracruz (Miller et al., 2005).
Previous records. Baja California: Río Hardy at El Mayor (Follett, 1960). *Baja California Sur*: none.
Recent records. Baja California: Río Colorado (before junction with Río Hardy and El Tapón) (Calvo-Fonseca, 2010); Presa Emilio López Zamora; and Río Hardy (south of El Mayor and El Mayor). *Baja California Sur*: none (Appendixes 1, 2).
Comments: The channel catfish was introduced in waters of the Río Colorado of California in 1922 (Dill and Cordone, 1997), but its presence in the Mexican part of this river was first documented by Follett (1960). Its current distribution has been expanded in the systems of channels for agriculture irrigation of the Mexicali Valley. This catfish is cultured commercially in a site adjacent to Río Hardy (Campo Mosqueda).
Ameiurus melas (Rafinesque, 1820)
Common name: black bullhead/bagre negro.
Native range: Atlantic slope, from Canada and the Great Lakes basin and Saint Lawrence River basin, southward between the Appalachian and Rocky Mountains, and into the Gulf Slope streams in the United States, just reaching the lower Río Bravo (Grande) in Nuevo Laredo, Tamaulipas, Mexico (Miller et al., 2005).
Previous records. Baja California: lower Río Colorado (Minckley, 1973).
Recent records. Baja California: none. *Baja California Sur*: none.
Comments: distribution in northwestern Mexico restricted to areas close to the international border, where the stocking in reservoirs for cattle is the most common way of dispersal. No voucher specimens have been reported.
Ameiurus natalis (Lesueur, 1819)
Common name: yellow bullhead/bagre torito amarillo.
Native range: native to eastern and central United States (Lee et al., 1980), including the Río Bravo (Grande) basin (Page and Burr, 1991).
Previous records: none.
Recent records. Baja California: Río Colorado (above junction with Río Hardy and El Tapón) (Calvo-Fonseca, 2010). *Baja California Sur*: none (Appendixes 1, 2).
Comments: the first records based on voucher specimens of yellow bullhead in the lower Río Colorado of Mexico were made by Ruiz-Campos (1995). This species was recorded for the Río Colorado in the United States in 1942 (Moyle, 2002). This bullhead also occurs in the Ciénega de Santa Clara, Sonora, Mexico (UABC- 661).
Ameiurus catus (Linnaeus, 1758)
Common name: white catfish/ bagre blanco.
Native range: Atlantic and Gulf slope drainages from the lower Hudson River, New York, to the Apalachicola basin in Florida, Georgia and Alabama; south in Peninsular Florida to the Peace River drainage (Fuller et al., 1999).
Previous records: none.
*Recent records. Baja California***:** Río Hardy at Dren de Ayala (Calvo-Fonseca, 2010). *Baja California Sur*: none.
Comments: the white catfish was first recorded in California in 1874 (Dill and Cordone, 1997), inhabiting the regions of the Sacramento, San Joaquín, coastal part of Central California, Tulare-Buena Vista Lakes and drainages of the San Francisco Bay (Fuller et al., 1999). Its presence in the Río Colorado was recently detected in the locality Río Hardy (Dren de Ayala) on 20 March 2008, based on 1 specimen of 431 mm TL and 1.055 kg weight (Calvo-Fonseca, 2010).
Pylodictis olivaris (Rafinesque, 1818)
Common name: flathead catfish/bagre pilntonte.
Native range: native of the Mississippi River basin, Missouri and Ohio Rivers, including northeastern Mexico in the Rio Bravo basin (Lee et al., 1980). This catfish is now established in the lower Río Colorado basin, including parts of Baja California and Sonora (Miller et al., 2005).
Previous records: none.
Recent records. Baja California: Laguna Salada (La Playita and its tributary channel; Compeán and Baylón, 1983); and the Río Colorado (downstream from the junction with Río Hardy and El Tapón (Calvo-Fonseca, 2010). *Baja California Sur*: none (Appendixes 1, 2).
Comments: the only voucher specimen (UABC-318, 440 mm LP) of this species from northwestern Mexico was captured in the junction of the Río Colorado and Río Hardy.

Order Cyprinodontiformes
Family Poeciliidae
Gambusia affinis (Baird and Girard, 1853)
Common name: western mosquito fish/pez mosquito.
Native range: Mississippi River basin from central Indiana and Illinois, USA, south through the Gulf of Mexico drainages and northern Veracruz (Álvarez del Villar, 1970; Page and Burr, 1991).
Previous records. Baja California: Río Hardy at Meganito; Río Colorado (downstream of the junction with Río Hardy, Pongo de Abajo, and above the mouth; cf. Follett, 1960); Río Tijuana (E Tijuana); stream near Valle de Las Palmas; stream near Ojos Negros (east of Ensenada); Arroyo Guadalupe (= La Misión) at Rancho Santa Rosa and the town of La Misión; and Arroyo San Simón (southern San Quintín) (Follett, 1960). *Baja California Sur*: stream at Santiago; stream at San José del Cabo (Follett, 1960); Ojo de Agua de La Rosita at San Antonio; Ojo de Agua de San Bartolo; stream near Ojos Negros (east of Ensenada);

Arroyo La Tinaja; and Presa Juárez (near Todos Santos) (Contreras-Balderas and Escalante-Cavazos, 1984).

Recent records. Baja California: Arroyo Alamar at Cañón del Padre; irrigation channel at Ejido Sinaloa (Varela et al., 2003); Arroyo El Descanso (mouth and adjacent lagoon); Arroyo Guadalupe or La Misión (mouth, Rancho Santa Rosa and Rancho Korodaki); stream between Piedras Gordas and Las Minas; Presa Emilio López Zamora; Arroyo San Carlos (Rancho Agua Caliente and Rancho Las Hamacas); Arroyo Las Ánimas; Arroyo Santo Tomás; Arroyo Seco (near Colonet); Arroyo San Telmo (mouth); Arroyo Santo Domingo (mouth and Rancho El Divisadero); Arroyo El Rosario (mouth and bridge of El Rosario); Ejido La Misión; irrigation channel between Ejido Nayarit and Ejido Sonora; Río Hardy at Campo Mosqueda; Río Colorado at Ejido Yucumuri; Laguna Salada (Paraíso fishery camp); and a small reservoir at Ejido El Porvenir (Rancho Tierra Santa). *Baja California Sur:* Arroyo La Tinaja (near Miraflores); Arroyo Boca de la Sierra at San Bernardino canyon (Ruiz-Campos et al., 2003) (Appendixes 1, 2).

Comments: western mosquito fish was introduced in northwestern Mexico for the control of mosquitoes; it became an invasive species due to its high tolerance and competitive capacity to extreme environmental factors (Contreras-Balderas et al., 2008). There are 2 sources of distribution of mosquito fish in the Baja California Peninsula, one from the northwestern between the Río Tijuana basin and Arroyo El Rosario (Ruiz-Campos et al., 2000) and the second for the south of La Paz (Ruiz-Campos et al., 2003). In northwestern Baja California it is considered a current competitor of the native threespine stickleback (*Gasterosteus aculeatus* Linnaeus, 1758), in the coastal streams of El Descanso, Santo Domingo, and El Rosario.

Poecilia latipinna (Le Sueur, 1821)

Common name: sailfin molly/topote velo negro.

Native range: Atlantic and Gulf of Mexico coastal drainages, from Cape Fear drainage, North Carolina, to Veracruz, Mexico (Fuller et al., 1999).

Previous records. Baja California: Río Hardy and Río Colorado (Hendrickson and Varela-Romero, 1989). *Baja California Sur:* none.

Recent records. Baja California: Río Hardy at Campo Mosqueda; the Río Colorado at Ejido Yucumuri; irrigation channel between Ejido Nayarit and Ejido Sonora (Varela-Romero et al., 2003); Río El Mayor at Campo Sonora; and Laguna Salada at El Paraíso fishery camp. *Baja California Sur:* none (Appendixes 1, 2).

Comments: the sailfin molly is one of many exotic fishes that have been introduced in the waters of the lower Río Colorado in California and Arizona (Dill and Cordone, 1997) and dispersed into the Mexican part of the basin. In the Ciénega de Santa Clara (Sonora) this fish competes with the endangered desert pupfish (*C. macularius*) for space and food (Varela-Romero et al., 2003).

Poecilia reticulata Peters, 1859

Common name: guppy/gupi.

Native range: West Indies and northern South America, from west Venezuela to Guyana (Fuller et al., 1999).

Previous records. Baja California: none. *Baja California Sur:* Presa Juárez near Todos Santos (Contreras-Balderas and Escalante-Cavazos, 1984).

Recent records. Baja California: Arroyo Cataviña; Arroyo Santa Gertrudis at Misión de Santa Gertrudis. *Baja California Sur:* Arroyo San José del Cabo; Arroyo Las Pocitas (Pozas del Vado and Rancho El Caracol); Arroyo San Pedro (San Basilio, Pozo del Iritú, Rancho Merecuaco, Rancho Los Arados, Rancho El Caporal, and San Pedro de La Presa); Arroyo Bebelamas (Poza Honda [Rancho San Lucas], Rancho El Frijolito, and Rancho San Antonio de la Montaña); Arroyo San Luis (Misión de San Luis Gonzaga, Presa Higuajil, and Rancho Las Cuedas); Arroyo La Zorra near Rancho Viejo; Arroyo San Javier at Misión de San (Francisco) Javier; Arroyo Comondú (San Miguel de Comondú and San José de Comondú); Arroyo La Purísima (La Purísima, near San Gregorio estuary, San Isidro, El Pilón, Carambuche, La Purísima-San Juanico road, and Ojo de Agua); Arroyo La Purísima Vieja at Paso Hondo; Oasis La Purísima Vieja; Río Mulegé (above dam); Arroyo Boca de Magdalena at San José de Magdalena; Arroyo San Joaquín (San Joaquín, El Sauzal, and San Zacarías); Arroyo San Ignacio (Oasis San Ignacio at spring and dam, Rancho El Tizón, Lake Side, San Lino, Poza Larga, Laguna Roberts, San Zacarías, and Rancho San Sabas); and San Gregorio stream at Sierra San Francisco (Appendixes 1, 2).

Comments: the guppy is the most invasive exotic fish in the freshwater bodies of the central and southern Baja California Peninsula, from Arroyo Cataviña (Baja California) to Arroyo San José del Cabo (Baja California Sur). From its first detection in 1977 at the tip of the Peninsula at Arroyo San José del Cabo (Ruiz-Campos and Contreras-Balderas, 1987), its dispersal in inland waters of the Peninsula has been rapid and favored by anthropogenic stocking. The presence of *P. reticulata* in very remote sites of the Sierra de San Francisco (Rancho San Gregorio) was previously reported by Ruiz-Campos et al. (2003).

Xiphophorus hellerii Heckel, 1848

Common name: green swordtail/cola de espada.

Native range: Middle America from Río Nantla, Veracruz (Mexico) to northwestern Honduras (Page and Burr, 1991; Fuller et al., 1999).

Previous records: none.
Recent records. Baja California: none. *Baja California Sur:* Arroyo San Pedro at San Basilio and San Pedro de la Presa; Arroyo San Ignacio (Oasis San Ignacio at spring, Rancho El Tizón, bridge (E and W), Poza Larga, San Lino, Paso Los Pinos between Los Corralitos and Rancho San Sabas, Lake Side, and San Sabas); and Arroyo San Joaquín at El Sauzal (Appendixes 1, 2).
Comments: this species is syntopical with the native Baja California killifish (*F. lima*) along the Arroyo San Ignacio (except for the locality of Los Corralitos) as well as in the Arroyo San Pedro de La Presa. The abundance of *X. hellerii* has been drastically reduced in the spring of San Ignacio due to the presence of another exotic competitor (the redbelly tilapa, *T.* sp. cf. *zillii*). Previous to the introduction of redbelly tilapia in the Arroyo San Ignacio in 1996, the green swordtail was the main competitor of the Baja California killifish (Alaníz-García et al., 2004).

Xiphophorus maculatus (Günther, 1866)
Common name: southern platyfish/espada sureña.
Native range: native to Atlantic drainages, along the Coastal Plain from the Río Nautla basin to northern Belize (Miller et al., 2005).
Previous records. Baja California: none. *Baja California Sur:* Ojo de Agua de La Rosita at San Antonio; Presa Juárez at Todos Santos (Contreras-Balderas and Escalante-Cavazos, 1984).
Recent records. Baja California: none. *Baja California Sur:* Arroyo San Luis at Misión de San Luis Gonzaga; Arroyo San Pedro (San Basilio, Pozo del Iritú, Rancho Merecuaco, and Rancho Tres Pozas); and Arroyo Los Dolores at Misión de Santa Dolores (Appendixes 1, 2).
Comments: the abundance of this alien livebearer seems to be declining in most sites of distribution in Baja California Sur, possibly due to diffuse competition with redbelly tilapia.

Xiphophorus variatus (Meek, 1904)
Common name: variable platyfish/espada de Valles.
Native range: native to the Atlantic slope of Mexico from southern Tamaulipas to northern Veracruz (Page and Burr, 1991).
Previous records. Baja California: Río Colorado at San Luis [Río Colorado] (Ruiz-Campos and Contreras-Balderas, 1987). *Baja California Sur*: none (Appendixes 1, 2).
Recent records: none.
Comments: although the occurrence of this fish in waters of California (USA) was confirmed in the Orange County and Salton Sea area in 1968 and 1991, respectively, its establishment has not been successful due the low temperatures that prevail during the winter (Dill and Cordone, 1997).

Orden Perciformes
Family Moronidae

Morone saxatilis (Walbaum, 1792)
Common name: striped bass/lobina estriada.
Native range: its native distribution is throughout the coastal drainages and littoral marine waters of the Atlantic, from Saint Lawrence River in New Brunswick, south to Saint Johns River in Florida (Ross, 2002).
Previous records: none.
Recent records. Baja California: Cerro Prieto or Solfatara channel. *Baja California Sur*: none (Appendixes 1, 2).
Comments: Dill and Cordone (1997) pointed out that the first transplantation of the striped bass in waters of the lower Río Colorado of California (USA) occurred in 1959. However, its presence in the the lower Río Colorado basin of Mexico had not been previously reported.

Family Centrarchidae

Lepomis gulosus (Cuvier, 1829)
Common name: warmouth/mojarra golosa.
Native range: native to Mississippi River drainages from northern Iowa on south, as well as to the Río Bravo (Grande) drainage, Gulf Coast drainages, Florida, and much of the Atlantic slope; some of the marginal populations could represent introductions (Moyle, 2002).
Previous records: none.
Recent records. Baja California: Río Pescadores at Rancho Caimán, and the Río Colorado near the junction with Río Hardy. *Baja California Sur:* none (Appendixes 1, 2).
Comments: in the Río Hardy, warmouth prefers backwaters of rivers and streams with turbidity, and muddy bottoms. Parasites detected in specimens from the Río Hardy were represented by *Ornithodiplostomum* sp. and the nematode *Contracaecum multipapillatum* (von Drasche, 1882), with percentages of prevalence of 2.93 and 17.94, respectively (Valles-Ríos, 1997).

Lepomis cyanellus Rafinesque, 1819
Common name: green sunfish/pez sol.
Native range: native to the Great Lakes, Hudson Bay, and Mississippi River basins from New York and Ontario to Minnesota and South Dakota, and south to the Gulf of Mexico drainages, including the Río Bravo (Grande) basin and northern Mexico (Page and Burr, 1991).
Previous records. Baja California: Río Tijuana (E of Tijuana); a stream near Valle de Santa Rosa, and Arroyo La Misión (= Guadalupe or San Miguel) (Follett, 1960).
Baja California Sur: none.
Recent records. Baja California: Arroyo El Descanso (mouth and adjacent lagoon); mouth of Arroyo La Misión; Arroyo San Antonio de las Minas at San Antonio de las Minas; Arroyo Doña Petra at Rancho Madrigal; Arroyo Guadalupe (Rancho Tierra Santa and Rancho Santa Rosa);

a small reservoir at the Parque Nacional Constitución 1857; Arroyo San Carlos at Rancho Las Hamacas; Arroyo Santo Tomás (Ejido Ajusco and La Bocana Santo Tomás); the mouth of Arroyo San Telmo; and Arroyo Santo Domingo at Rancho El Divisadero. *Baja California Sur*: none (Appendixes 1, 2).

Comments: the non-native presence of green sunfish in the streams of the northwestern region of Baja California was first reported by Follett (1960) for the Santa Rosa Valley (a tributary of the Arroyo Guadalupe). This exotic centrarchid is a possible predator of the native threespine stickleback (*Gasterosteus aculeatus*) in the mouth of the Arroyo El Descanso and its adjacent lagoon (Sánchez-Gonzáles et al., 2001).

Lepomis macrochirus Rafinesque, 1819

Common name: bluegill/mojarra oreja azul.

Native range: native to eastern and central North America where it ranges from coastal Virginia to west Texas and northern Mexico, and in the northwestern Minnesota to western New York. Widely introduced in the United States (Lee et al., 1980) and northwestern Mexico (Contreras-Balderas and Escalante-Cavazos, 1984).

Previous records: none.

Recent records. Baja California: Cerro Prieto or Solfatara channel; Laguna Hanson at Sierra Juárez; and Presa Emilio López Zamora. *Baja California Sur*: none (Appendixes 1, 2).

Comments: this fish is considered of recent introduction in the inland waters of northwestern Baja California, being first collected at Laguna de Hanson in 1983 (Ruiz-Campos et al., 2000), almost 6 years before the drying of this lake in 1989.

Lepomis microlophus (Günther, 1859)

Common name: redear sunfish/mojarra oreja roja.

Native range: southeastern United States from northern Florida to North Carolina, along Gulf of Mexico drainages to Texas, and north to Indiana. Commonly stocked outside its natural distribution including areas in the northeastern and western United States (Ross, 2002).

Previous records: none.

Recent records. Baja California: Río Colorado at Ejido Yucumuri (Appendixes 1, 2).

Comments: the record cited above represents the second known of this taxon in Mexico and is based on 80 individuals.

Micropterus salmoides **(**Lacepède, 1802)

Common name: largemouth bass/lobina negra.

Native range: Mississippi River basin, Atlantic coast states of USA and Gulf of Mexico, including northeastern Mexico. It is one of the sport fishes more widely introduced in freshwater reservoir systems of the world (Moyle, 2002).

Previous records. Baja California: Río Tijuana (E of Tijuana); Laguna San Simón near Bahía San Quintín; Río Hardy (Meganito and south of El Mayor); and Río Colorado (before and downstream of the junction with Río Hardy; Follett, 1960). *Baja California Sur:* none.

Recent records. Baja California: Río Colorado near junction with Río Hardy; Presa Emilio López Zamora; and irrigation channel between Ejido Nayarit and Ejido Sonora. *Baja California Sur:* none (Appendixes 1, 2).

Comments: largemouth bass has been repeatedly introduced in small and large reservoirs of northwestern Mexico to promote sport fishing. In Baja California, the species is also known to occur in the General Abelardo L. Rodríguez (Tijuana), El Carrizo (Tecate), and Emilio López Zamora (Ensenada) reservoirs, including stockings in the semi permanent Laguna Hanson and other water bodies of the region.

Pomoxis annularis Rafinesque, 1818

Common name: white crappie/robaleta blanca.

Native range: originally distributed in the freshwaters of the eastern and central North America, southeastern Ontario and southwestern New York, western Appalachian Mountains, south to the Gulf of Mexico, Texas, South Dakota, and Minnesota. Widely stocked in the United States and lower Río Bravo (Grande) for sport fishing (Lee et al., 1980).

Previous records. Baja California: Río Colorado: south of Presa Morelos and downstream of the junction with Río Hardy (Follett, 1960). *Baja California Sur:* none.

Recent records. Baja California: Río Colorado and Río Hardy (Calvo-Fonseca, 2010). *Baja California Sur:* none (Appendixes 1, 2).

Comments: this exotic game fish is syntopical with *P. nigromaculatus* in the lower Río Colorado basin (Minckley, 2002), and its dispersal into the Mexican part of this basin was from the large reservoirs of Arizona.

Pomoxis nigromaculatus **(**Lesueur, 1829)

Common name: black crappie/robaleta negra.

Native range: this centrachid fish is native to eastern North America, including the Atlantic drainage from Virginia to Florida, east to central Texas and north to North Dakota (Ross, 2002). Widely introduced in other states of the United States (Fuller et al., 1999), including the lower Río Colorado basin (Dill and Cordone, 1997).

Previous records. Baja California: Río Colorado (south of Presa Morelos and downstream of Pongo de Abajo; Follett, 1960). *Baja California Sur:* none.

Recent records. Baja California: Laguna Salada at La Playita and the Río Colorado (before the junction with Río Hardy and at Ejido Yucumuri). Calvo-Fonseca (2010) recently recorded this species for the Río Colorado and Río Hardy. *Baja California Sur:* none (Appendixes 1, 2).

Comments: the first record of black crappie in inland waters

of Baja California was reported by Follett (1960). This exotic fish species of interest for sport fishing dispersed into the Mexican portion of the Río Colorado from the large reservoirs of Arizona (USA) (Minckley, 1973, 2002).

Family Cichlidae

Oreochromis aureus (Steindachner, 1864)

Common name: blue tilapia/tilapia azul.

Native range: tropical and subtropical Africa, and the Middle East. Its native range includes Senegal, Niger and many smaller drainages in Africa and the Middle East (Fuller et al., 1999).

Previous records: none.

Recent records. Baja California: Laguna Salada at La Playita, and the Río Colorado (Minckley, 2002). *Baja California Sur:* hybrid individuals of this species have been detected at the Arroyo San Javier near Misión de San Javier (Appendixes 1, 2).

Comments: this Ethiopian cichlid has been progressively introduced in many freshwater bodies of Mexico both natural and artificial for aquaculture and commercial catch. Its high capacity of competition for resources like space and food has caused the displacement of native fishes such as *Cyprinodon macularius* Baird and Girard 1853 in the lower Río Colorado basin of Baja California and Sonora (Varela-Romero et al., 2003).

Oreochromis mossambicus (Peters, 1852)

Common name: mozambique tilapia/tilapia mosambica.

Native range: eastern coast of Africa, inhabiting rivers and coastal lagoons (Fuller et al., 1999).

Previous records: none.

Recent records. Baja California: Laguna Salada (El Paraíso fishery camp and channel tributary); Río Hardy at Campo Mosqueda; Río Colorado at Ejido Yucumuri; and irrigation channel between Ejido Nayarit and Ejido Sonora. *Baja California Sur*: Arroyo La Purísima at El Pilón, and Arroyo Las Pocitas at El Pilar (Appendixes 1, 2).

Comments: this alien cichlid is one of the most popular fish for the development of rural and commercial aquaculture, and to a lesser extent for sport fishing. Invasion of this fish in rivers and streams adjacent to reservoirs of stocking is causing the decline of the native fish populations in Sonora (Varela-Romero and Hendrickson, 2010).

Tilapia* sp. cf. *zillii (Gervais, 1848)

Common name: redbelly tilapia/tilapia panza roja.

Native range: tropical and subtropical Africa, Near East; West Africa through the Chad basin to the Nile River, Lake Albert, and Lake Turkana into Israel and the Jordan Valley. This cichlid has been widely introduced in many regions of the world (Fuller et al., 1999; Moyle, 2002).

Previous records: none.

Recent records. Baja California: Río El Mayor at Campo Sonora; irrigation channel between Ejido Nayarit and Ejido Sonora (Varela-Romero et al., 2003); Presa Emilio López Zamora; and Arroyo San Juan de Dios at Rancho El Saucito. *Baja California Sur*: Arroyo San Ignacio (spring, Rancho El Tizón, Lake Side, bridge (E and W), San Lino, Poza Larga, Rancho Los Estribos, Lagunita de Roberts, Rancho Los Corralitos, Rancho los Pinos, and Rancho San Sabas); Arroyo San Joaquín at San Joaquín; Arroyo Cadejé at Cadejé; Arroyo Boca de Magdalena at San José de Magdalena; Arroyo San Martín at Rancho La Vinorama (Sierra de Guadalupe); Arroyo La Purísima (near San Gregorio estuary, San Isidro, El Pilón, La Purísima-San Juanico road, La Purísima, Carambuche, Presa Carambuche, and Ojo de Agua); Arroyo La Purísima Vieja (oasis and Paso Hondo); Arroyo Comondú at San Miguel de Comondú; Arroyo San Javier (oasis and Misión de San [Francisco] Javier); Arroyo Bebelamas (Rancho San Antonio de la Montaña, Poza Honda, and Rancho El Frijolito); Arroyo San Luis (Misión de San Luis Gonzaga, Presa Higuajil, and Rancho Las Cuedas); Arroyo San Pedro (San Pedro de La Presa, San Basilio, Pozo del Iritú, Rancho Merecuaco, Rancho Los Arados, and Rancho Tres Pozas); Arroyo La Soledad at Rancho El Quelele; Arroyo Las Pocitas at Rancho El Cantil; and Arroyo San José del Cabo (Appendixes 1, 2).

Comments: redbelly tilapia is one of the most invasive exotic fishes in the inland waters of the Peninsula of Baja California (Ruiz-Campos et al., 2003, 2006; Varela-Romero et al., 2003) and southwestern United States (Dill and Cordone, 1997). In the lower Río Colorado basin, this fish is the main cause of the decreasing abundance and distribution of the desert pupfish, *C. macularius* (Schoenherr, 1988; Varela-Romero et al., 2003); likewise, in the oases of Baja California Sur it has caused the extirpation of the endemic Baja California killifish (*F. lima*) in the localities of San Javier, Las Cuedas, Misión de San Luis Gonzaga, San Pedro de La Presa (Ruiz-Campos, 2010), and Bebelamas (Poza Honda). The redbelly tilapia was first stocked into the oasis of San Ignacio in 1995. Previous to the introduction of redbelly tilapia in this last locality, the Baja California killifish was the dominant fish in the spring habitat with relative abundances between 70 and 97% (Alaníz-García, 1995); however, 10 years later, the redbelly tilapia now has the highest relative abundances (84-94%) (Ruiz-Campos et al., 2008).

Discussion

The exotic fish fauna for the continental waters of the Baja California Peninsula is currently represented by 27 species belonging to 16 genera and 7 families. The highest number of exotics (21) are recorded for

the lower Río Colorado basin, with most coming from central and eastern North America and representative of primary freshwater families such as Ictaluridae (6 spp.) and Centrarchidae (7 spp.). The high number of exotic fish species in the lower Río Colorado basin of Mexico is a result of the introduction of species over almost a century in the different reservoirs of the Río Colorado in the United States, promoting dispersal downstream (Dill, 1944; Miller, 1952; Minckley, 1973, 2002). Significant fluctuations in the base flow of the Río Colorado has generated the extirpation of fish species associated with high flow conditions such as the endemics, *Xyrauchen texanus* (Abbott, 1860), *Gila elegans* (Baird and Girard, 1853), and *Ptychocheilus lucius* (Girard, 1856) (Rinne and Minckley, 1991; Varela-Romero and Hendrickson, 2010), as well as the establishment of exotic fishes tolerant to these hydrological changes such as *C. lutrensis*, *P. latipinna*, *G. affinis*, and *T.* sp. cf. *zillii* (Varela-Romero et al., 2003), all of them have dispersed into the agriculture irrigation channels in the Mexicali Valley. In this same basin, but in spring and wetland habitats, the abundance of the desert pupfish *C. macularius* Baird and Girard 1853 has dramatically decreased (Follett, 1960; Hendrickson and Varela-Romero, 1989; Varela-Romero et al., 2003; Miller et al., 2005), mainly because of competition with redbelly tilapia and sailfin molly (Varela-Romero et al., 2003).

The process of invasion of aquatic species into new areas involves three steps that compress the initial dispersal, establishment, and radiation (Elton, 2000). In each one of these steps there are selective pressures operating on the survival of organisms in the new areas and that determine the success of invasion (Williamson, 1996). In this sense, three main hypotheses, not mutually exclusive, have been formulated to explain the patterns of invasion: human activity, biotic acceptance, and biotic resistance. The first hypothesis concerns the steps of initial invasion, establishment, and radiation, while the second hypothesis predicts that the establishment of nonnative species will be higher for areas rich in native species, where the abiotic conditions are favorable for both; finally, the biotic resistance hypothesis explains that the success of the invasion decreases in relation to the species richness in the community (Gido and Brown, 1999; Leprieur et al., 2008) and the time of accumulation of species.

Based on niche theory (Chase and Leibold, 2003), 2 species occurring together in space and time cannot have identical realized niches because one would be excluding the other. The invasive exotic species with ample potential niches become dominant when are introduced in aquatic systems containing few native species with specialized ecological niches. This advantage of competition is also evidenced in those signicantly altered habitats, promoting thus the expression of the potential niches of the exotic species with ample environmental tolerances.

The oases of Baja California Sur, characterized by a low diversity of native fish, contain endemic species such as the Baja California killifish (*Fundulus lima*) and Baja freshwater clingfish (*Gobiesox juniperoserrai* Espinosa-Pérez and Castro-Aguirre, 1996), as well as forms of marine or peripheral derivation such as *Awaous banana* (Valenciennes, 1837), *Eleotris picta* Kner, 1863, *Gobiomorus maculatus* (Günther, 1859), *Dormitator latifrons* (Richardson, 1844), and *Agonostomus monticola* (Bancroft, 1834) (Follett, 1960; Ruiz-Campos et al., 2003). The first introduction of exotic redbelly tilapia in Baja California Sur occurred in the La Purísima basin in 1976 (Ruiz-Campos, 2000); the species was repeatedly stocked into others basins causing the local extirpation of the endemic killifish and peripheral fishes in the oases of San Javier, San Pedro de la Presa, Las Cuedas, San Luis Gonzaga (Ruiz-Campos, 2010), and Bebelamas (Poza Honda). In the oasis of San Javier, the population of Baja California killifish was extirpated because of the introduction of redbelly tilapia. Likewise, in the oasis of San Pedro de la Presa, both Baja California killifish and 4 peripheral species (*A. monticola*, *D. latifrons*, *G. maculatus*, and *E. picta*) were displaced by competition of redbelly tilapia (Ruiz-Campos et al., 2003). In the oases of Las Cuedas, San Luis Gonzaga (Mission), and Bebelamas, the populations of Baja California killifish were eliminated by competitive exclusion with tilapia.

The eradication of exotic fishes in northwestern Mexico is a goal that is very difficult to achieve because of the invasive potential of some species with well established distributions in the open lotic ecosystems (streams and rivers). One of the strategies that might reduce the impacts of the exotics on the natives is the implementation of permanent programs of removing exotic fishes using active and passive capture techniques. The use of toxicants for fishes (ichthyocides) such as rotenone or antimicine could give good results by removing undesirable or exotic fishes when applied in a systematic manner in closed systems such as ponds, reservoirs and springs (Bettoli and Maceina, 1996). Previous to the treatment with the toxicant, all the native species must be captured and transported live to be stocked into temporal habitats or refugia. As soon as the original ecological conditions of the system have been recovered, the native fishes should be returned to their original habitats.

As in other arid and semiarid regions of the world, in the Baja California Peninsula, the exotic fish species are more abundant and better naturalized, and consequently the native species are more threatened and, in some cases with high probabilities of extinction in the short term.

Detailed information on the distribution and abundance of the exotic fish fauna in the Baja California Peninsula is critically needed for implementation of official programs to address the management and control of these alien species and of their habitats. Only education through the information will ensure that society understands that the conservation of native fishes, regardless of its economic value, is a great moral obligation (Andreu-Soler et al., 2006; Andreu-Soler, 2008).

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Appendix 1. Examined material of exotic fishes from the Baja California peninsula, Mexico. The collecting site is followed by catalog number and number of specimens in square brackets.

Poecilia reticulata

Baja California: Arroyo ca. Cataviña (UABC-726 [42], 877 [75]); La Bocana at Cataviña (UABC-1350 [3]), and Arroyo Santa Gertrudis at Santa Gertrudis Mission (UABC-2321 [327]). **Baja California Sur:** Arroyo San José del Cabo at San José del Cabo (UABC-754 [1]); Presa (dam) Juárez at Todos Santos (UANL-2569 [303]); Arroyo Las Pocitas at Poza del Vado (UABC-1563 [65], 1575 [20]) and Rancho El Caracol (UABC-1564 [11], 1576 [24], 1577 [50], 1582 [99], 1592 [9]); Arroyo San Pedro at San Basilio (UABC-780 [39]), Pozo del Iritú [Encinas] (UABC-784 [69], 1574 [14]), Rancho Merecuaco (UABC-793 [50]), Rancho Los Arados (UABC-1583 [8]), and San Pedro de La Presa (UABC-1317 [42], 1321 [31], 1419 [1], 1485 [6]); Arroyo El Caporal at Rancho El Caporal (UABC-1307 [50]); Arroyo Bebelamas at Poza Honda [Rancho San Lucas] (UABC-746 [37], 2359 [62]), Rancho El Frijolito (UABC-749 [71], 2357 [42]) and San Antonio de la Montaña (UABC-1311 [18]); Arroyo San Luis [dam] at Misión de San Luis Gonzaga (UABC-752 [196], 757 [23], 1579 [19]), Presa Higuajil (UABC-742 [2]), and Rancho Las Cuedas (UABC-1301 [62], 1578 [30], 1586 [34]); Arroyo La Zorra near Rancho Viejo (UABC-1483 [117]); Arroyo San Javier [dam] at Misión de San [Francisco] San Javier (UABC-822 [170], 823 [61], 912 [7], 2354 [24], 2355 [6]); Arroyo Comondú at San Miguel de Comondú (UABC-765 [339]), and San José de Comondú (UABC-763 [149], 764 [162]); Arroyo La Purísima near San Gregorio estuary (UABC-2158 [2], San Isidro (UABC-727 [5], La Purísima [dam and bridge] (UABC-761 [48], 827 [1]), El Pilón (UABC-1501 [1]), Carambuche [Cuba] (UABC-760 [16], 828 [1]), 1529 [1]), Presa (dam) Carambuche (UABC-761 [48], 827 [1]), bridge of Carambuche (UABC-1533 [12]), and Ojo de Agua (UABC-1467 [25], 1580 [22]); La Purísima Vieja at Paso Hondo (UABC-1466 [7], 1554 [19]); Río Mulegé [above dam] (UABC-146 [83], 907 [7]); Arroyo Boca de Magdalena at San José de Magdalena (UABC-737 [18], 908 [26]); Arroyo San Joaquín at San Joaquín (UABC-733 [81], El Sauzal (UABC-734 [11], 1474 [76]) and San Zacarías (UABC-075 [36]); Oasis San Ignacio at spring (UABC-080 [51], 936 [26], 1306 [58], 2129 [2]), El Tizón (UABC-1536 [7]), Lake Side (UABC-1437 [39], 1496 [2]), San Lino (UABC-1527 19]), Poza Larga (UABC-1314 [18], 1447 [76], 1457 [40], 1503 [2], 2133 [1]), Laguna Roberts (UABC-1497 [32]), San Sabas (UABC-1456 [40], 1502 [4]); and Arroyo San Gregorio at Sierra San Francisco (UABC-725 [138]).

Gambusia affinis

Baja California: Stream near Valle de Las Palmas (CAS-119067, 119246); Ojos Negros (CAS-119247); Arroyo Alamar at Cañón del Padre (UABC-1351 [1]); mouth of Arroyo El Descanso (UABC-409 [14], 411 [710]) and its adjacent lagoon (UABC-435 [7], 481 [6], 996 [27]); mouth of Arroyo La Misión (UABC-216 [2], 487 [7]; UANL-13720 [8]), Arroyo La Misión at La Misión [town] (UABC-050 [3], 073 [9]); Arroyo Guadalupe at Rancho Santa Rosa (UABC-376 [65], 875 [14]) and Rancho Korodaki [= fall of Agua Caliente] (UABC-1297 [29]); mouth of Arroyo San Miguel [= El Carmen] (UABC-201 [10], 488 [99]); stream between Piedras Gordas and Las Minas (UABC-1356 [3]); Presa (dam) Emilio López Zamora [reservoir] (UABC-1593 [1]); Arroyo San Carlos at ranches

Appendix 1. Continues.

of Las Hamacas (UABC-932 [7]) and Agua Caliente [hot spring] (UABC-954 [3]); Arroyo Las Animas (UABC-1360 [54]); Arroyo Santo Tomás [Ejido Ajusco] (UABC-605 [2]), Arroyo Seco [near Colonet] (UABC-317 [56]), Arroyo San Telmo (UABC-169 [61], 312 [315], 471 [26]); mouth of Arroyo Santo Domingo (UABC-166 [1], 310 [9]); Arroyo Santo Domingo at Rancho El Divisadero, UABC-455 [112], 592 [30], 1026 [12]); Arroyo El Rosario [lower part] (UABC-160 [2], 162 [30], 309 [14], 320 [56], 458 [130], 462 [12], 584 [32], 892 [3], 959 [[1], 1024 [7], 2094 [13], 2096 [15], 2100 [1], 2109 [1]); Río Colorado at channel tributary of Laguna Salada (USON-174 [1]); Río Hardy at Campo Mosqueda (USON-191 [114]); Río Hardy at Campo Mosqueda [La Cabaña] (USON-204 [1098]); Río Colorado at Ejido Yucumuri [Campo Escondido] (USON-196 [347]; Laguna Salada at Paraíso fishery camp (USON-209 [27]); and irrigation channel between Ejido Nayarit and Ejido Sonora (USON-214 [28]). **Baja California Sur:** Ojo de Agua de La Rosita (UANL-2543 [44]); Ojo de Agua de San Bartolo (UANL-2547 [383]); Arroyo La Tinaja near Miraflores (UANL-2553 [49], UABC-751 [88]); Arroyo Boca de la Sierra (UABC-767 [29]); and Presa (dam) Juárez near Todos Santos (UANL-2568 [75]).

Poecilia latipinna

Baja California: Río El Mayor at Campo Sonora (UABC-100 [46], 135 [7], 136 [15]); Río Hardy at Campo Mosqueda (USON-192 [224]); Río Hardy at Campo Mosqueda [La Cabaña] (USON-205 [1941]); Río Colorado at Ejido Yucumuri (USON-197 [13], 953 [57]); Laguna Salada at Paraíso fishery camp (USON-210 [1]); and irrigation channel between Ejido Nayarit and Ejido Sonora (USON-215 [1802], 921 [9], 929 [19], 966 [45], 989 [68]).

Xiphophorus hellerii

Baja California Sur: Arroyo San Pedro at San Basilio (UABC-781 [60]) and San Pedro de la Presa (UABC-1320 [67], 1417 [92]); Arroyo San Ignacio at spring (UABC-079 [36], 147 [5], 187 [6], 722 [1], 1305 [6], 1407 [9], 1468 [16], 1500 [123]), El Tizón (UABC-1470 [3], 1535 [4]), Lake Side (UABC-1438 [3], 1498 [1]), bridge of San Ignacio (UABC-1445 [4], 1446 [14]), Poza Larga (UABC-1308 [5], 1315 6], 1316 [11], 1418 [32], 1448 [31], 1458 [21], 1499 [6], 1504 [2], 2127 [11], 2128 [1]), San Lino (UABC-1526 [3]), Paso Los Pinos (UABC-1476 [1], 2092[1]), and San Sabas (UABC-1505 [20]); and Arroyo San Joaquín at El Sauzal (UABC-1475 [2]).

Xiphophorus maculatus

Baja California Sur: Ojo de Agua de La Rosita at San Antonio (UANL-2544 [82]); Presa Juárez (dam) at Todos Santos (UANL-2570 [36]); Arroyo San Luis (dam) at Misión de San Luis Gonzaga (UABC-768 [74]); Arroyo San Pedro at San Basilio (UABC-782 [108]), Pozo del Iritú (UABC-787 [24]), and Rancho Merecuaco (UABC-794 [19]); and Arroyo Los Dolores at Misión de Santa Dolores (UABC-1461 [7]).

Dorosoma petenense

Baja California: Channel tributary to Laguna Salada (UABC-114 [2], USON-176 [17]); Río Colorado before junction with Río Hardy (UABC-107 [10], 122 [7], 132 [3]); Río Hardy before junction with Río Colorado (UABC-130 [58]); Río El Mayor at Campo Sonora (UABC-085 [26], 133 [9], 134 [6]); Presa Emilio López Zamora [reservoir] (UABC-1588 [1]); Río Hardy at campo Mosqueda (USON-0194 [40]); Río Hardy at Campo Mosqueda [La Cabaña] (USON-0207 [177]); Río Colorado at Ejido Yucumuri (USON-0203 [119]); and irrigation channel between Ejido Nayarit and Ejido Sinaloa (USON-0219 [180]).

Carassius auratus

Baja California Sur: Río Hardy before junction with Río Colorado (UABC-428 [2]); Laguna Salada at Paraíso fishery camp (USON-0211 [1]); and irrigation channel between Ejido Nayarit and Ejido Sonora (USON-0217 [1], 951 [51], 965[94]).

Cyprinella lutrensis

Baja California: Río Hardy at Campo Mosqueda (USON-190 [286]; Río Colorado at Ejido Yucumuri [Campo Escondido] (USON-201 [10]; and irrigation channel between Ejido Nayarit and Ejido Sonora (USON-216 [407]).

Cyprinus carpio

Baja California: Channel tributary to Laguna Salada (UABC-117 [8]), Río Colorado before junction with Río Hardy (UABC-222 [1], 108 [1], 414 [2], 951 [2]). **Baja California Sur:** Arroyo San Ignacio at spring (UABC-076 [1], 721 [1], 1361 [1]), bridge of Arroyo San Ignacio (UABC-1449 [2], 1537 [2]), Poza Larga (UABC-1300 [3], 1428 [23], 1506 [11], 1538 [3], 1608 [15]), Los Corralitos (UABC-1453 [2], 1551 [2], 2121 [5]), and San Sabas (UABC-1550 [1]).

Ictalurus punctatus

Baja California: Río Colorado before junction with Río Hardy (UABC-105 [9]); and Presa Emilio López Zamora [reservoir] (UABC-1050 [3]).

Ameiurus natalis

Baja California: Río Colorado before junction with Río Hardy (UABC-091 [1], 093 [3], 123 [1]).

Pylodictis olivaris

Baja California: Río Colorado downstream of the junction with Río Hardy (UABC-318 ([1]).

Morone saxatilis

Baja California: Cerro Prieto or Solfatara channel (UABC-1318 [5]).

Lepomis gulosus

Baja California: Río Pescadores at Rancho Caimán (UABC-1051 [4]); and Río Colorado before junction with Río Hardy (UABC-104 [2], 412 [1]).

Appendix 1. Continues.

Lepomis cyanellus

Baja California: Arroyo El Descanso (adjacent lagoon, UABC-177 [1]); mouth of Arroyo La Misión (UABC-865 [1]); Arroyo San Antonio de las Minas at Rancho Kodoraki (Ruiz-Campos, pers. obs.), and Rancho La Fortuna (UABC-2051 [25]); Arroyo Cañón de Doña Petra [tributary of Arroyo Guadalupe] at Rancho Madrigal (UABC-1491 [1]); Arroyo Guadalupe at Rancho Tierra Santa [Ejido El Porvenir] (UABC-183 [16], 665 [33]) and Rancho Santa Rosa (UABC-377 [4], 876 [1]); pool at Parque Nacional Constitución 1857 (UABC-1488 [1]); Arroyo Santo Tomás at Ejido Ajusco (UABC-224 [2]) and La Bocana Santo Tomás (UABC-452 [1]); and mouth of Arroyo San Telmo (UABC-311 [6]).

Lepomis macrochirus

Baja California: Cerro Prieto or Solfatara channel (UABC-1319 [1]); Laguna Hanson at Sierra Juárez (UABC-077 [4]); and Presa Emilio López Zamora [reservoir] (UABC-415 [3], 1280 [2]).

Lepomis microlophus

Baja California: Río Colorado at Ejido Yucumuri (USON-199 [80]).

Micropterus salmoides

Baja California: Río Colorado before junction with Río Hardy (UABC-223 [1]), 217 [1], 218 [1]); Presa Emilio López Zamora [reservoir] (UABC-413 [4], 1279 [1]); Río Colorado at Ejido Yucumuri (USON-198 [2]); irrigation channel between Ejido Nayarit and Ejido Sonora (USON-968 [4], 991 [1]).

Pomoxis nigromaculatus

Baja California: Laguna Salada at La Playita (UABC-090 [1]); Río Colorado before junction with Río Hardy (UABC-140 [1]); and Río Colorado at Ejido Yucumuri (USON-200 [4]).

Oreochromis aureus

Baja California: Laguna Salada at La Playita (UABC-0830 [1]).

Oreochromis mossambicus

Baja California: Channel tributary to Laguna Salada (USON-75 [145]); Río Hardy at campo Mosqueda (USON-193 [40]); Río Hardy at Campo Mosqueda [La Cabaña] (USON-206 [2988]); Río Colorado at Ejido Yucumuri (USON-202 [114]); Laguna Salada at Paraíso fishery camp (USON-212 [17]); irrigation channel between Ejido Nayarit and Ejido Sonora (USON-218 [156], 922 [1], 930 [3], 967 [1]).

Tilapia* sp. cf. *zillii

Baja California: Río El Mayor at Campo Sonora (UABC-109 [17], 119 [1]); Presa Emilio López Zamora [reservoir] (UABC-1037 [1]); Arroyo San Juan de Dios at El Saucito (UABC- 1653 [188]); and irrigation channel betwen Ejido Nayarit and Ejido Sonora (USON-990 [7]). **Baja California Sur:** Arroyo Las Pocitas at Rancho El Cantil (UABC-2363 [3]), Arroyo La Soledad at Rancho El Quelele (UABC-2246 [6]); Arroyo San Pedro at San Pedro de La Presa (UABC-1322 [5], 1329 [1], 1423 [224]), San Basilio (UABC-783 [18], 1424 [12]), Pozo del Iritú (UABC-788 [13], 1562 [11], 1573 [16]), Rancho Merecuaco (UABC-792 [4]), Rancho Los Arados (UABC-1572 [16], 1584 [23]), and Rancho Tres Pozas (UABC-795 [3]); Arroyo San Luis at Misión de San Luis Gonzaga (UABC-739 [13], 1571 [15], 1585 [23]), and Rancho Las Cuedas (UABC-744 [3], 750 [5], 1303 [39], 1570 [13], 1587 [17]); Arroyo Bebelamas at Rancho San Antonio de la Montaña (UABC-1310 [60]), Poza Honda [Rancho San Lucas] (UABC-747 [126], 2358 [13]), and Rancho El Frijolito (UABC-748 [1], 2360 [81]); Presa (dam) Higuajil (UABC-741 [18]); Arroyo San Javier at Misión de San (Francisco) Javier (UABC-819 [3], 820 [73], 821 [22], 911[13], 1545 [92], 2356 [4]); Arroyo Comondú at San Miguel de Comondú (UABC-766 [1]); Arroyo La Purísima Vieja at Paso Hondo (UABC-1546 [39], 1558 [57]); Oasis La Purísima Vieja (UABC-1547 [22], 1557 [5]); Arroyo La Purísima near San Gregorio estuary (UABC-2157 [14]), San Isidro (UABC-728 [2]), El Pilón (UABC-1441 [30], 1482 [3], 1511 [277]), bridge of Carambuche (UABC-1531 [8]), La Purísima (UABC-762 [90], 825 [34]), Carambuche [= Cuba] (UABC-759 [38], 826 [8], 1299 [2], 1528 [2]), Presa (dam) Carambuche (UABC-1302 [15], 1408 [39], 1415 [33], 1440 [15], 1523 [43]), and Ojo de Agua (UABC-1406 [11], 1410 [27], 1412 [7], 1420 [41], 1427 [2], 1429 [10], 1439 [3], 1510 [36]), 1548 [1]); Arroyo San Martín at Rancho La Vinorama [Sierra de Guadalupe] (UABC-738 [1]); Oasis San Ignacio at spring (UABC-942 [10], 1304 [30], 1469 [149], 1495 [127], 2091 [28]), El Tizón (UABC-1442 [78], 1534 [21]), Lake Side (UABC-1459 [86], 1521 [14]), San Ignacio [bridge of] (UABC-1443 [1], 1444 [4]), San Lino (UABC-1525 [18]), Poza Larga (UABC-1494 [1], 1509 [82], 1520 [14], 1581 [11], 2130 [10], 2131 [73], 2132 [25]), Rancho Los Estribos (UABC-1411 [30], 1414 [26]), Lagunita de Roberts (UABC-1519 [19]), Rancho Los Corralitos (UABC-1454 [2], 1455 [30], 1507 [4], 1552 [1], 2085 [63], 2086 [81], 2087 [71]), Rancho Los Pinos (UABC-2084 [44], 2088 [26], 2089 [23], 2090 [51]), and Rancho San Sabas (UABC-1493 [2], 1508 [15], 1522 [4], 1549 [1]).

Appendix 2. Geographical coordinates of the collecting sites for exotic fish species in the Baja California Peninsula, Mexico.

Locality	*Geographical coordinates*	*Code*
Baja California		
Arroyo Alamar	32º31'27.5" N, 116º54'46.8" W	AA
Arroyo San Antonio de las Minas at San Antonio de las Minas	31º58'32.2" N, 116º37'55.4" W	AAM
Arroyo Las Ánimas at Ejido Uruapan	31º37'00.0" N, 116º26'00.0" W	AAN
Arroyo Cataviña near of Cataviña	29º43'37.0" N, 114º42'46.9" W	AC-01
Arroyo Cataviña near of Cataviña	29º52'45.8" N, 114º56'59.9" W	AC-02
Arroyo Cañón de Doña Petra at Rancho Madrigal	31º55'20.9" N, 116º36'13.4" W	ACP
Arroyo El Descanso (lagoon)	32º12'16.5" N, 116º54'46.6" W	ADE-01
Mouth of Arroyo El Descanso (= La Posta)	32º12'09.3" N, 116º54'47.8" W	ADE-02
Arroyo Seco near of Colonet	31º05'56.1" N, 116º10'58.9" W	ASE-01
Arroyo Guadalupe at Rancho Tierra Santa (Ejido El Porvenir)	32º05'00.0" N, 116º37'00.0" W	AGU-01
Arroyo Guadalupe at Rancho Korodaki	32º06'15.8" N, 116º27'03.4" W	AGU-02
Arroyo Guadalupe at Rancho Santa Rosa (= El Salto)	32º13'43.9" N, 116º55'21.6" W	AGU-03
Mouth of Arroyo Guadalupe	32º05'32.0" N, 116º52'50.0" W	AGU-04
Arroyo Guadalupe at La Misión	32º05'45.0" N, 116º51'30.0" W	AGU-05
Stream between Piedras Gordas and Las Minas	31º55'46.1" N, 116º27'04.7" W	APG
Mouth of Arroyo El Rosario	30º02'32.5" N, 115º47'15.6" W	ARO-01
Arroyo El Rosario at the Rosario's bridge	30º03'14.9" N, 115º43'32.6" W	ARO-02
Arroyo El Rosario (mouth)	30º03'14.9" N, 115º43'31.2" W	ARO-03
Arroyo El Rosario (mouth)	30º03'14.9" N, 115º47'07.7" W	ARO-04
Arroyo El Rosario (mouth)	30º02'20.7" N, 115º46'06.3" W	ARO-05
Arroyo Santa Gertrudis at Misión de Santa Gertrudis	28º03'2.00" N, 113º05'3.50" W	ASAG-01
Arroyo San Carlos at Balneario Agua Caliente	31º46'0.00" N, 116º31'0.00" W	ASC-01
Arroyo San Carlos at Rancho Las Hamacas	31º47'51.6" N, 116º30'02.4" W	ASC-02
Arroyo Santo Domingo at Rancho El Divisadero	30º46'21.4" N, 115º54'19.5" W	ASD-01
Mouth of Arroyo Santo Domingo near of San Ramón	30º42'53.6" N, 116º02'31.6" W	ASD-02
Stream near Valle de Santa Rosa	32º13'43.9" N, 116º55'21.6" W	ASR
Mouth of Arroyo San Simón near Hotel La Pinta	30º24'24.1" N, 115º54'24.3" W	ASS
Mouth of Arroyo San Telmo near of Punta San Telmo	30º56'29.5" N, 116º14'57.6" W	ASTE-01
Arroyo Santo Tomás at Ejido Ajusco	31º35'00.0" N, 116º28'00.0" W	ASTO-01
Mouth of Arroyo Santo Tomás	31º32'12.9" N, 116º39'28.0" W	ASTO-02
Stream near Valle de las Palmas (SE Tecate)	32º22'42.0" N, 116º36'56.0" W	ATE
Channel Cerro Prieto or Solfatara (= Pacífico)	32º30'0.00" N, 115º27'0.00" W	CCP-01
Irrigation channel between Ejido Nayarit and Ejido Sonora	32º17'41.3" N, 115º15'20.5" W	CENS
Small reservoir at Parque Constitución	32º00'10.8" N, 115º56'50.5" W	CHSJ
Ejido La Misión	32º05'45.0" N, 116º51'30.0" W	EM
Arroyo San Juan de Dios at El Saucito	30º06'51.8" N, 115º21'18.9" W	LASJD
Laguna Hanson (Sierra Juárez)	32º02'00.0" N, 115º54'00.0" W	LH
Channel effluent to Laguna Salada	31º58'0.00" N, 115º13'0.00" W	LSA-01
La Playita, northwestern edge of Laguna Salada	32º31'0.00" N, 115º45'0.00" W	LSA-02
Laguna Salada at Paraíso fishery camp	32º38'0.00" N, 115º39'0.00" W	LSA-03
Ojos Negros (E Ensenada)	31º54'40.9" N, 116º16'19.1" W	ON
Presa Emilio López Zamora (reservoir)	31º54'08.5" N, 116º35'37.8" W	PELZ
Río Colorado before junction with Río Hardy	32º06'0.00" N, 115º13'45.0" W	RC-01
Río Colorado (downstream of the junction with the Río Hardy)	32º02'9.93" N, 115º12'20.4" W	RC-02
Río Colorado at Pongo de Abajo	31º59'47.8" N, 115º03'34.4" W	RC-03
Río Colorado (40 km above the mouth)	32º03'6.30" N, 115º08'53.9" W	RC-04
Río Colorado (S of Morelos reservoir)	32º36'55.7" N, 114º52'52.4" W	RC-05
Río Colorado (downstream of Pongo de Abajo)	31º59'57.0" N, 115º04'18.5" W	RC-06
Río Colorado at San Luis	32º29'33.8" N, 114º48'49.6" W	RC-07
Río Colorado at Ejido Yucumuri (Campo Escondido)	32º05'0.00" N, 115º10'0.00" W	RC-10

Appendix 2. Continues.

Río Colorado at El Tapón	32º02’53.28” N,115º11’08.9”W	RC-11
Río Hardy before junction with Río Colorado	32º06’0.00” N, 115º14’15.0” W	RH-01
Río Hardy at Meganito (N El Mayor)	32º10’16.8” N, 115º17’2.23” W	RH-02
Río Hardy (S El Mayor)	32º07’28.8” N, 115º15’54.7” W	RH-03
Río Hardy at Campo Mosqueda	32º05’0.00” N, 115º12’0.00” W	RH-05
Río Hardy at Dren-Ayala	32º02’13.15” N,115 º 08’15.2” W	RH-06
Río El Mayor at Campo Sonora	32º00’4.00” N, 115º18’0.00” W	RM-01
Río Pescadores at Rancho Caimán	32º13’30.0” N, 115º11’30.0” W	RPE-01
Río Tijuana (E Tijuana)	32º31’19.2” N, 117º00’21.9” W	RTI-01
Dam in Rancho Tierra Santa (Ejido El Porvenir)	32º05’0.00” N, 116º37’0.00” W	RTS
Baja California Sur		
Arroyo Bebelamas at Rancho San Lucas (Poza Honda)	24º57’44.6” N, 111º20’17.9” W	AB-01
Arroyo Bebelamas at Poza de la Caguama (= Rancho San Antonio de la Montaña)	24º57’33.8” N, 111º19’21.1” W	AB-02
Arroyo Bebelamas at Rancho El Frijolito (= El Frijol)	24º57’29.0” N, 111º19’06.0” W	AB-03
Arroyo Boca de Magdalena at San José de Magdalena	27º04’08.7” N, 112º12’07.9” W	ABM-01
Arroyo Boca de Magdalena at San José de Magdalena	27º09’00.0” N, 112º14’00.0” W	ABM-02
Arroyo Boca de la Sierra at San Bernardino canyon	23º23’10.6” N, 109º49’11.7” W	ABS
Arroyo Comondú at San José de Comondú	26º03’32.4” N, 111º49’29.3” W	ACO-01
Arroyo Comondú at San Miguel de Comondú	26º01’57.6” N, 111º49’58.3” W	ACO-02
Arroyo Las Pocitas at Pozas del Vado	24º23’0.00” N, 111º06’0.00” W	APO-01
Arroyo Las Pocitas at Rancho El Caracol	24º32’0.00” N, 111º01’0.00” W	APO-02
Arroyo Las Pocitas at Rancho El Cantil	24º35’28.3” N, 110º59’36.1” W	APO-03
Arroyo La Purísima near San Gregorio estuary	26º9’56.3” N, 112º114’44.9” W	APU-01
Arroyo La Purísima at Carambuche (= Cuba)	26º12’58.6” N, 112º01’12.9” W	APU-02
Arroyo La Purísima at San Isidro	26º12’29.4” N, 112º02’26.6” W	APU-09
Arroyo La Purísima at Ojo de Agua	26º19’24.2” N, 111º59’09.7” W	APU-03
Arroyo La Purísima at La Purísima-San Juanico road	26º09’32.2” N, 112º07’42.2” W	APU-04
Arroyo La Purísima at Presa (dam) Carambuche	26º14’19.8” N, 112º00’03.6” W	APU-05
Arroyo La Purísima at La Purísima	26º10’58.7” N, 112º05’18.5” W	APU-06
Arroyo La Purísima Vieja at Paso Hondo	26º20’08.2” N, 112º09’48.2” W	APU-07
Arroyo La Purísima at El Piloncillo (El Pilón)	26º12’01.9” N, 112º03’55.8” W	APU-08
Arroyo La Purísima Vieja at La Purísima Vieja	26º18’39.9” N, 112º09’43.8” W	APU-10
Stream in Santiago	23º28’17.7” N, 109º43’36.9” W	ASA
Arroyo San Gregorio at Rancho San Gregorio (Sierra San Francisco)	27º40’35.5” N, 113º01’02.8” W	ASG-01
Arroyo San Ignacio at Lake Sade	27º17’56.0” N, 112º53’39.0” W	ASI-01
Arroyo San Ignacio at Los Corralitos	27º13’01.9” N, 112º59’16.9” W	ASI-02
Arroyo San Ignacio at Paso Los Pinos	27º12’37.3” N, 112º09’54.8” W	ASI-03
Arroyo San Ignacio at Poza Larga	27º16’26.1” N, 112º54’46.5” W	ASI-04
Arroyo San Ignacio at bridge of access to the town: San Ignacio	27º17’51.3” N, 112º53’50.8” W	ASI-05
Arroyo San Ignacio (bridge W)	27º17’52.5” N, 112º53’49.6” W	ASI-06
Arroyo San Ignacio at San Lino	27 º17’52.1”N, 112 º54’17.6”W	ASISL
Arroyo San Ignacio at El Tizón	27º17’53.2” N, 112º53’12.3” W	ASI-07
Arroyo San Ignacio at Rancho Los Estribos	27º15’40.2” N, 112º55’40.9” W	ASI-08
Arroyo San Ignacio at San Sabas	27º11’51.8” N, 113º00’09.3” W	ASI-09
Arroyo San Ignacio at San Zacarías	27º08’0.00” N, 112º54’0.00” W	ASI-10
Oasis San Ignacio at spring	27º17’48.3” N, 112º52’55.1” W	ASI-12
Oasis San Ignacio (dam)	27º18’0.00” N, 112º53’0.00” W	ASI-13
Arroyo San Ignacio at Laguna Roberts	27º14’43.6” N, 112º57’31.6” W	ASI-14
Arroyo San Javier at Misión de San (Francisco) Javier	25º52’07.0” N, 111º32’49.0” W	ASJ-01
Oasis San Javier at San Javier	25º52’1.20” N, 111º32’43.0” W	ASJ-02
Stream (Ojo de Agua) at San José del Cabo	23º03’32.0” N, 109º41’28.8” W	ASJC
Arroyo San Joaquín at San Joaquín	27º11’0.00” N, 112º51’0.00” W	ASJO-01
Arroyo San Joaquín at El Sauzal	27º10’0.00” N, 112º52’0.00” W	ASJO-02
Arroyo San Joaquín at San Zacarías	27º08’0.00” N, 112º54’0.00” W	ASJO-03

Appendix 2. Continues.

Arroyo San Luis at Misión de San Luis Gonzaga	24º54'34.8" N, 111º17'21.5" W	ASLU-01
Arroyo San Luis at Presa Higuajil (dam)	24º58'22.7" N, 111º23'37.2" W	ASLU-02
Arroyo San Luis at Rancho Las Cuedas	24º53'59.4" N, 111º14'58.7" W	ASLU-04
Arroyo San Martín at Rancho La Vinorama	26º38'14.0" N, 112º17'27.0" W	ASMA-01
Arroyo La Soledad at El Quelele	24º48'37.5" N, 110º50'32.5" W	ASO
Arroyo San Pedro at San Basilio	24º50'13.1" N, 111º04'37.4" W	ASPE-01
Arroyo San Pedro at Pozo del Iritú (=Rancho Encinas)	24º46'55.0" N. 111º09'02.4" W	ASPE-02
Arroyo San Pedro at Rancho Los Arados	24º47'06.5" N, 111º11'07.2" W	ASPE-03
Arroyo San Pedro at Rancho Merecuaco	24º48'25.2" N, 111º09'03.6" W	ASPE-04
Arroyo San Pedro at Rancho Tres Pozas	24º48'58.1" N, 111º07'33.0" W	ASPE-05
Arroyo San Pedro at San Pedro de la Presa	24º51'0.00" N, 110º59'0.00" W	ASPE-06
Arroyo San Pedro at Rancho El Caporal	24º49'47.5" N, 111º13'09.5" W	ASPE-07
Arroyo La Tinaja (= El Aguajito) near Miraflores	23º21'59.4" N, 109º45'19.2" W	ATI
Arroyo La Zorra near Rancho Las Parras	25º57'20.2" N, 111º31'06.8" W	AZO
Arroyo Los Dolores at Misión Santa Dolores	25º04'27.1" N, 110º51'40.1" W	MSD
Ojo de Agua de la Rosita at San Antonio	23º48'20.1" N, 110º03'41.0" W	OARO
Ojo de Agua de San Bartolo	23º44'11.0" N, 109º50'25.0" W	OASB
Presa Juárez (dam) near Todos Santos	23º32'44.4" N, 110º08'44.1" W	PJU
Río Mulegé between the bridge and the mouth	26º53-54'0.0" N, 111º57-58'0.0" W	RMU-01